



POLITECNICO
MILANO 1863



Ospedale Luigi Sacco
AZIENDA OSPEDALIERA - POLO UNIVERSITARIO

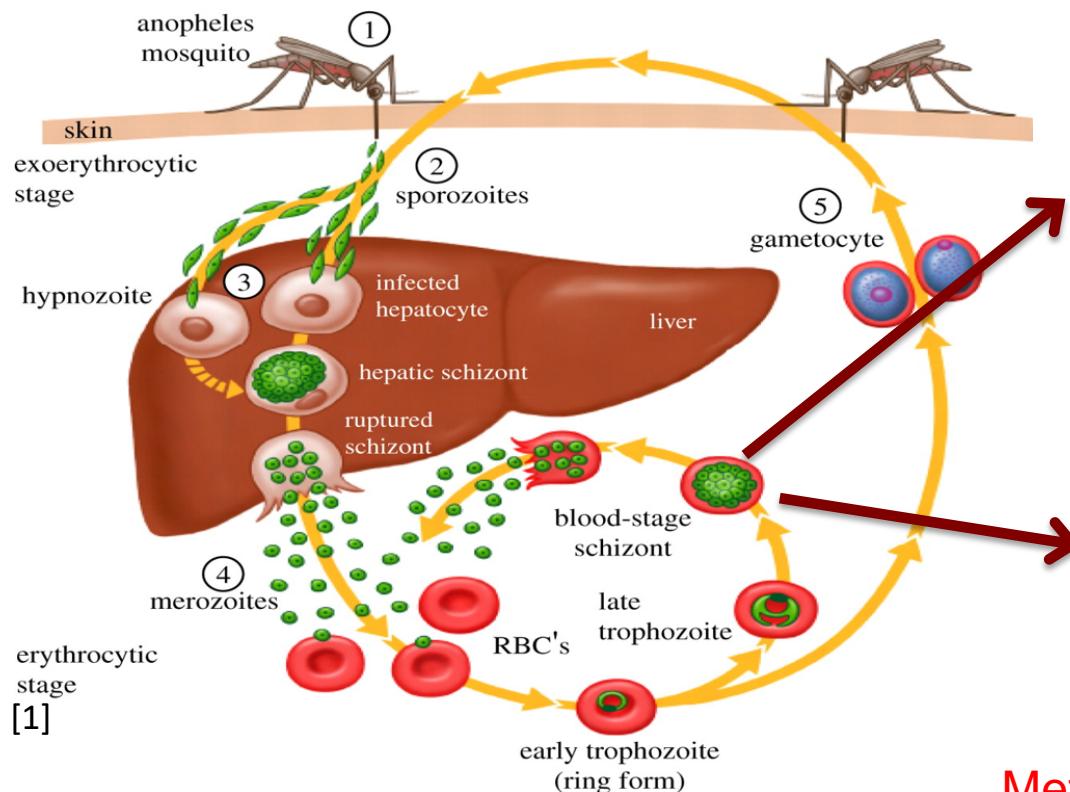


TMek: a lab-on-chip diagnostic test for Malaria disease

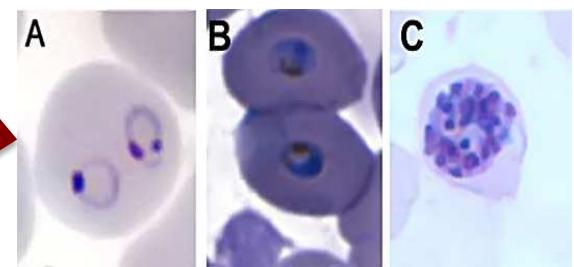
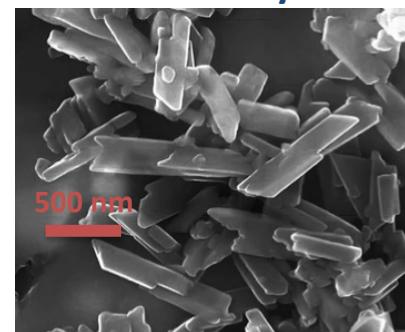
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Disease development



Hematozoin crystals



Infected red blood cells (i-RBCs)

Methods for malaria diagnosis



GOLD STANDARD



PCR



RAPID DIAGNOSTIC TEST

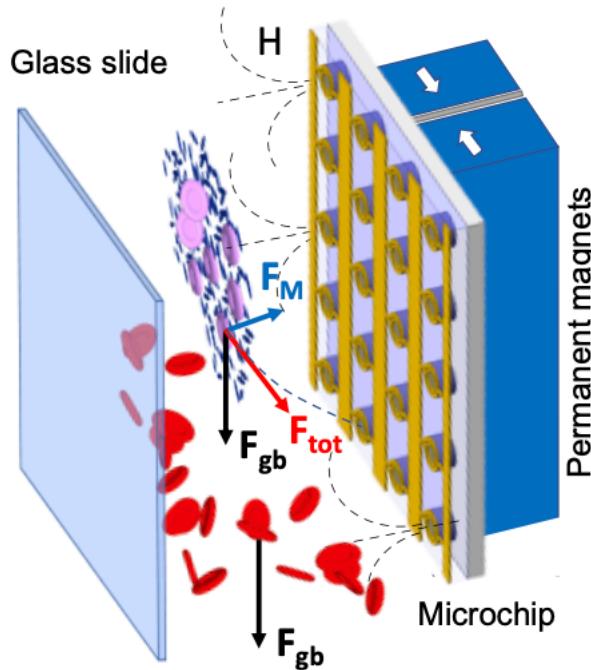
[1] Hill et al., "Vaccines against malaria", Philosophical transactions of the Royal Society, 2011.

[2] P.N. Simao, "Exploring impedance spectroscopy as a mean of malaria diagnostic", PhD thesis, IST, 2014.

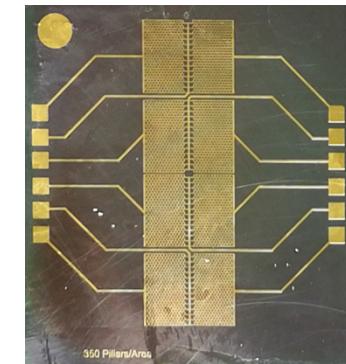
Idea of the TMek project



Need of a **compact**, **low-cost** and **easy to use** diagnostic system, which allows a **rapid** detection, with the same **sensitivity** of the Gold Standard

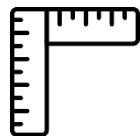


- Specific **magnetic attraction** of infected red blood cells
- Quantification through an **impedance variation detection**



5MIN

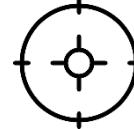
TIME-SAVING



**QUANTITATIVE
METHOD**



PANPLASMODIC
SENSITIVITY
(PARASITAEMIA)



0.0002%



SINGLE
DROPLET
ON-CHIP



NO QUALIFIED
PERSONNEL

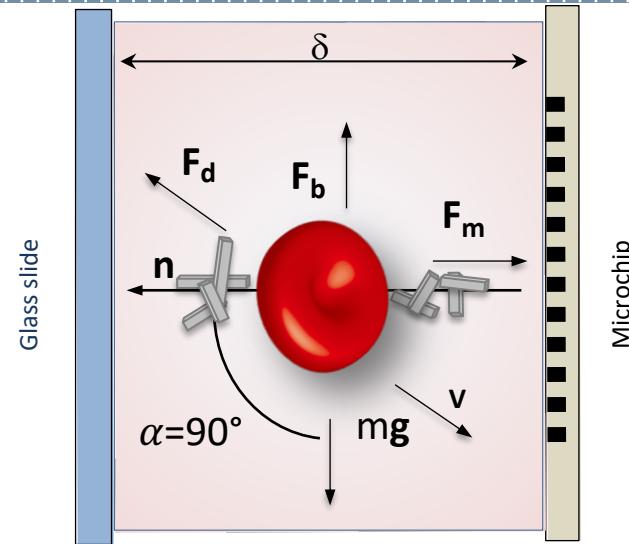
Magnetophoretic capture of particles in fluid

Resultant force acting on the particle:

$$F_{magnetic} + F_{buoyancy} - F_{gravity} - F_{drag}$$

$$F_{magnetic} = \frac{\mu_0}{2} V p \Delta\chi \nabla(H(x))^2$$

- $0,01 \cdot 10^{-6}$ for Healthy Red Blood Cells
- $+1,8 \cdot 10^{-6}$ for Infected Red Blood Cells (schizont stage)
- $+3,9 \cdot 10^{-6}$ for Treated Red Blood Cells
- $+320 \cdot 10^{-6}$ for Hemozoin Crystals



$\nabla(H(x))^2$ minimum

$$1,56 \cdot 10^{17} \frac{A}{m^3}$$

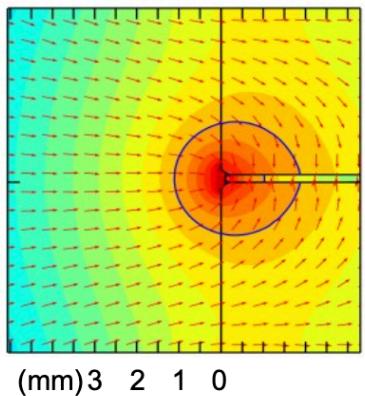
$$8,6 \cdot 10^{14} \frac{A}{m^3}$$

$$4 \cdot 10^{14} \frac{A}{m^3}$$

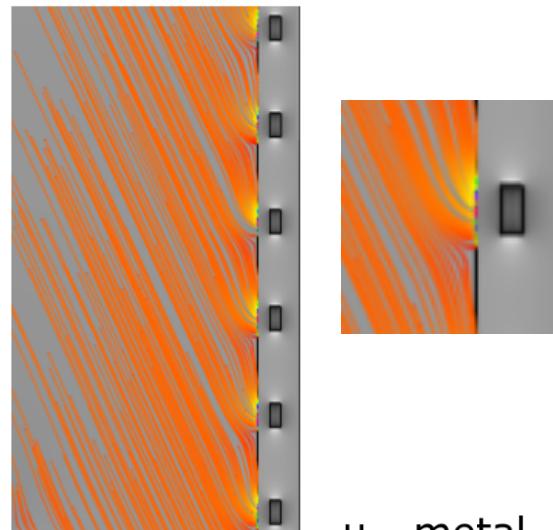
$$2,26 \cdot 10^{13} \frac{A}{m^3}$$

Field gradient generation

NdFeB
Permanent
magnets

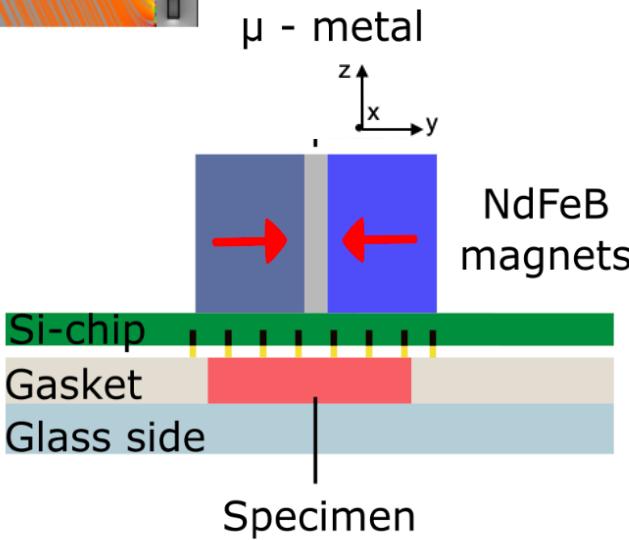
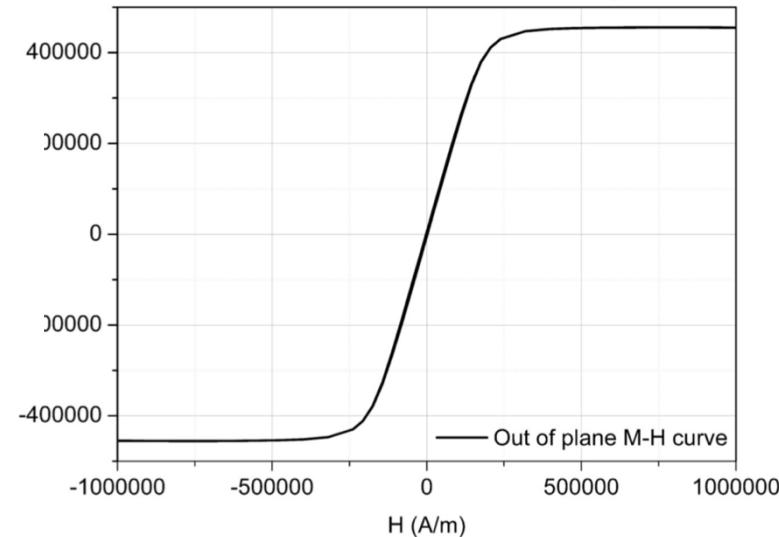


Nickel microstructures



Permanent magnets

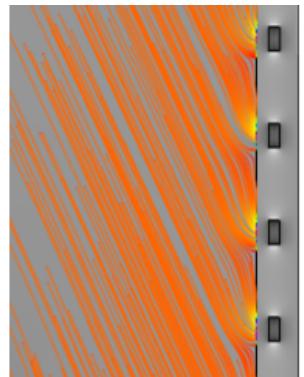
- ✓ Long range attracting force.
- ✓ Avoid or slow-down sedimentation.



Nickel microstructures

- ✓ Local field strengthening.
- ✓ Concentration of particles onto the electrodes.

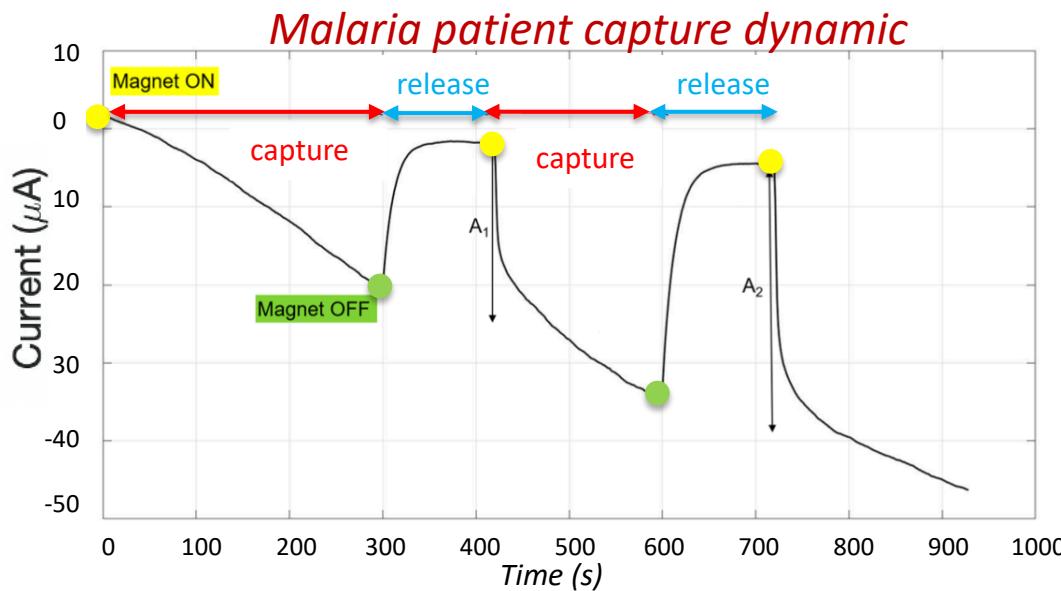
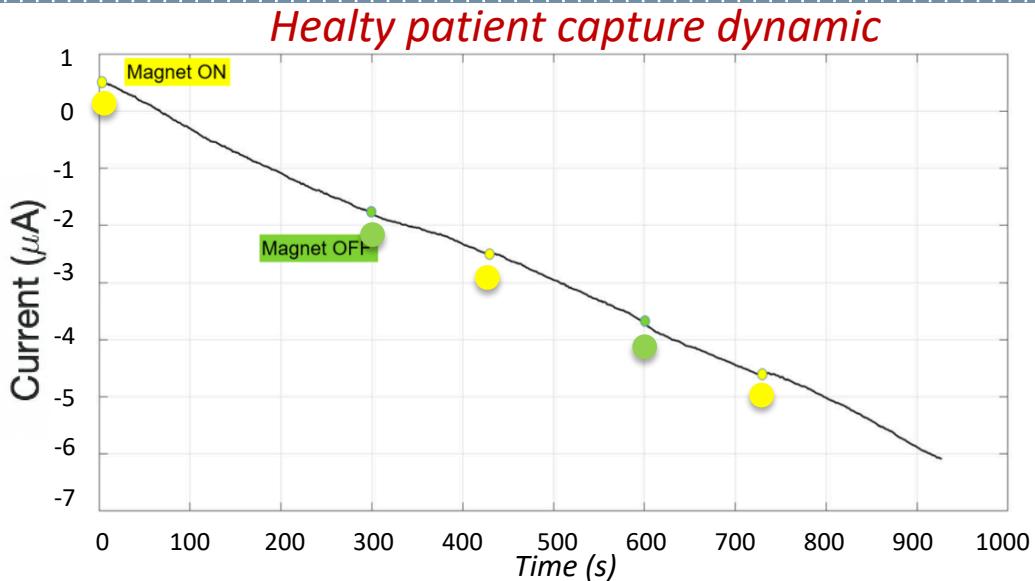
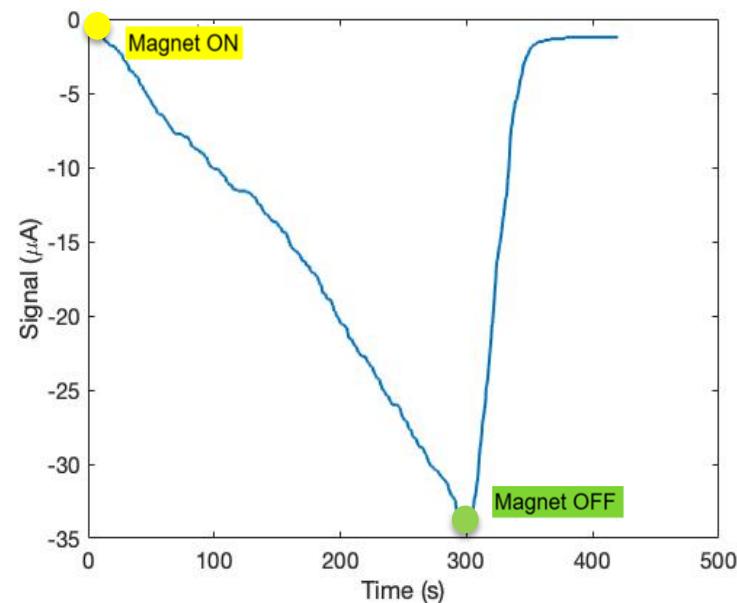
t-RBCs capture dynamics: simulations and real signals



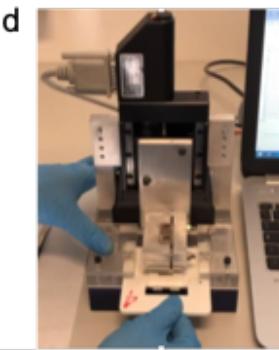
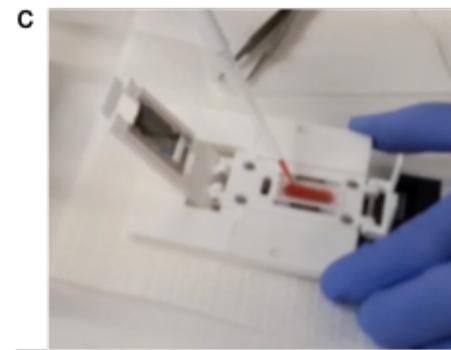
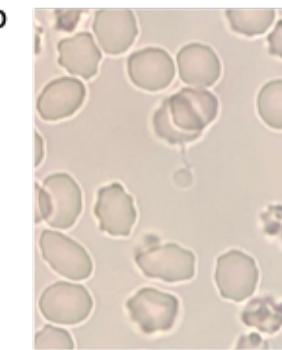
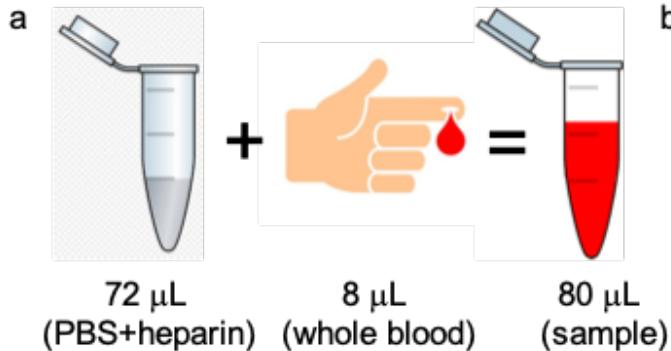
Particle trajectories



COMSOL simulation signal amplitude vs time



ProtoC: setup suitable for validation



Easy sample preparation:
Prick sampling + dilution

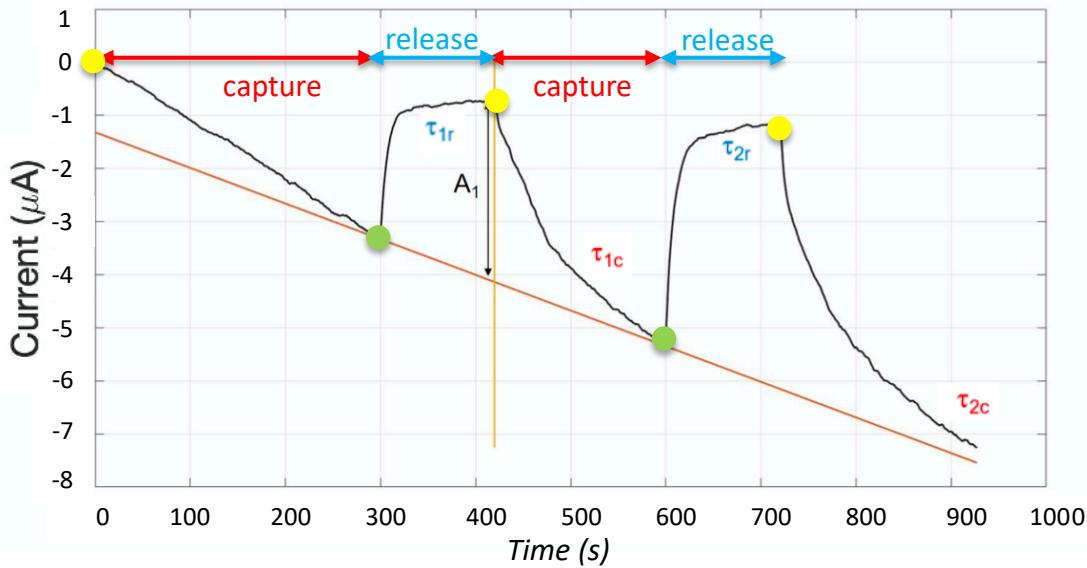
Floating RBC

**Sample loading on a
cartridge with the
microchip**

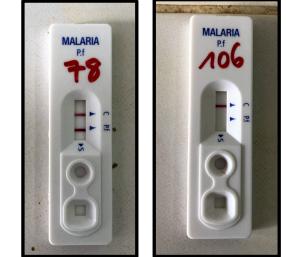
**Cartridge
insertion in the
reader**

Comparative performances of TMek and lateral flow RDT

Result	TMek (Venous)	RDT	TMek (Capillary)
True positive (n)	46	45	8
False positive (n)	10	5	0
False negative (n)	0	1	0
True negative (n)	19	24	2
Sensitivity (%) [95% CI]	100 (90.3-100)	97.8 (87-99.8)	100.0 (63.0 - 100.0)
Specificity (%) [95% CI]	65.5 (45.5-81.4)	82.7 (63.5-93.4)	100.0 (15.8 - 100.0)
Positive predictive value (%) [95% CI]	82.1 (69.1-90)	90 (77.4-96.2)	100
Negative predictive value (%) [95% CI]	100 (79-100)	96 (77.6-99.7)	100



TMek



RDT Bioline



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Thank you for your attention